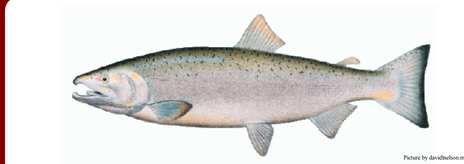

Picture by Wilfred Swancourt Bronser

Salmonids by Numbers II

Ian J. Mallett - 2010


Picture by davidhelson.md

Introduction

The San Lorenzo River in California is home to two species of anadromous, ecologically important, iconic fish: the "Steelhead" Rainbow Trout (*Oncorhynchus mykiss*) and the "Silver" Coho Salmon (*Oncorhynchus kisutch*), known collectively by their taxonomic family *salmonidae* as "salmonids". Recently, their respective local populations in the San Lorenzo Valley Watershed have dropped precipitously. Today, Coho salmon are almost nonexistent in most tributaries, while Rainbow Trout populations are similarly falling quickly.

The San Lorenzo Valley High School Watershed Academy, in cooperation with the Monterey Bay Salmon and Trout Project (MBS&TP), has collected census counts and other data on spawning salmonids migrating upstream in the San Lorenzo River over a number of years at an inflatable dam near Felton Covered Bridge Park. There are also USGS-collected daily average stream flow data taken at a nearby location available online.

Last year, I showed, statistically, how streamflow can be used as a rough predictor of fish upstream migratory patterns. However, this only provides a very rough estimate, and a major remaining computational problem is the accurate prediction of future fish populations in the San Lorenzo and elsewhere. In this study, I am considering more factors than streamflow to make a more accurate model based on simulation rather than on statistics. For every simulated day over an arbitrary number of years, distributions of real-world factors are applied to reasonable estimates of a simulated fish populations to predict the real population's future.

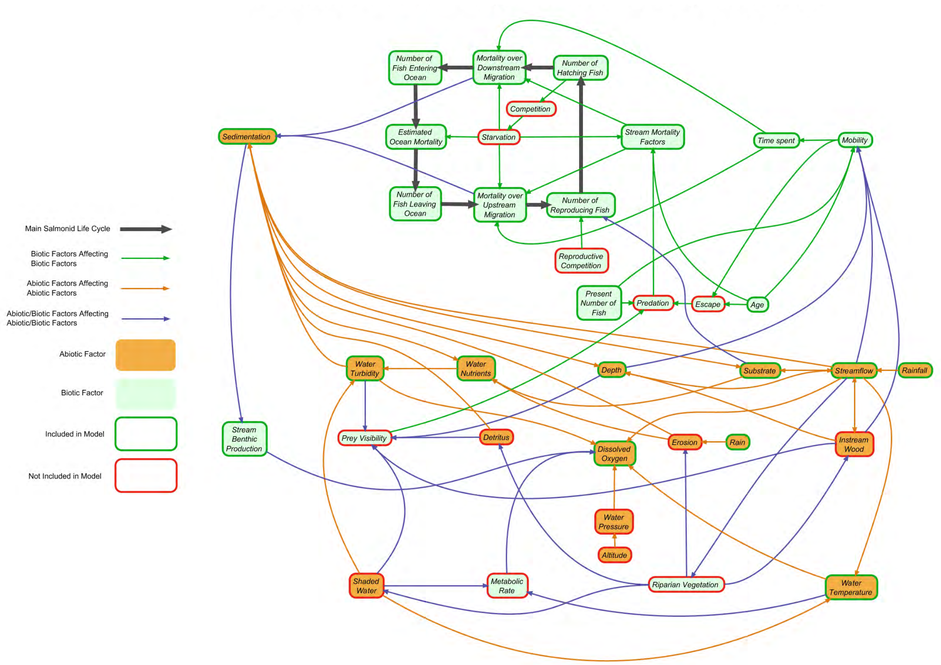
Materials

- Copies of raw data about the fish, taken daily by many observers from San Lorenzo Valley High School and the Monterey Bay Salmon and Trout Project at the fish trap in Felton during spawning season since 2000
- Data available online from the United States Geological Survey about daily local average stream flow near Felton
- Information on salmonid lifecycles and the factors that affect them, from various sources, including Don Alley et al.
- Fathom statistical software, (student ed.)
- OpenOffice Calc/Writer/Impress
- Microsoft Excel
- VUE mind-mapping software
- TI-89 Platinum graphing calculator
- Python 2.5.4 programming language

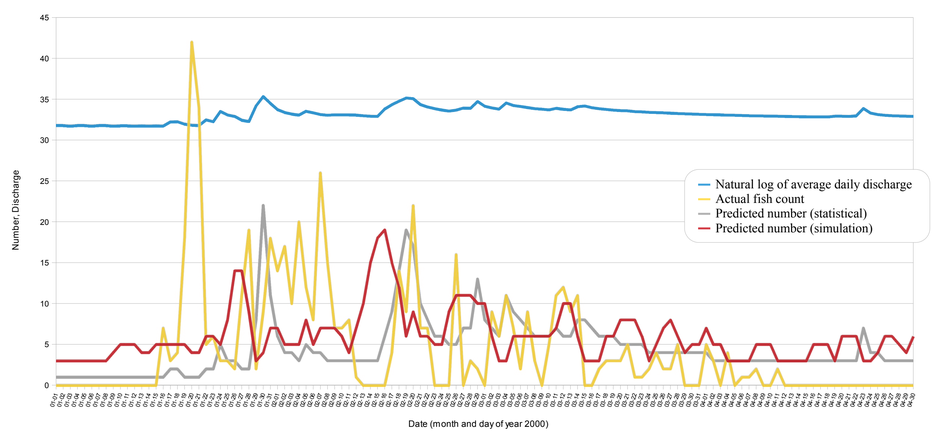
Methods and Assumptions

- Using VUE, I constructed a detailed chart showing all of the documented interrelated factors affecting salmonid populations (based on research by Don Alley et al., the MBS&TP, myself, and others). *See top chart: Factors Influencing Salmonid Populations*
- Using the Python programming language, I constructed a basic day-by-day simulation scheme.
- Beginning with the most basic, I added factors affecting salmonid populations to the simulation. In cases where real data is not known, I used distributions based on estimates of real parameters instead. The factors were allowed to affect each other as per the chart. I tested the factors individually as they were added, to ensure consistency and functionality against the 2001, 2003, 2004, 2007, and 2008 datasets that I compiled last year (these data will be available online soon). Factors included in the simulation are bordered green in the top chart.
- Using the process of elimination of variables, I adjusted the simulation parameters slightly to produce results that correlate more precisely with the real life data.
- To confirm that the simulation is accurate, I compared predicted results with the year 2000 dataset, which was not used in the construction of the simulation. *See lower chart: Comparing Simulations*

Factors Influencing Salmonid Populations



Comparing Simulations



Results

The effort to simulate fish populations has been successful. A rough sensitivity analysis of the simulation indicates that the most important factors that affect salmonid migrations are streamflow and sedimentation. Further, these factors must remain within relatively narrow boundaries for salmonid success. In the top chart, we intuitively see this is because these two factors provide key links between the upper salmonid lifecycle and the lower stream ecosystem.

As seen in the lower chart, preliminary simulations roughly replicate observed population trends in the year 2000 dataset. The results obtained from the simulation are not more accurate than my statistical model that considers only streamflow. However, the simulation has the advantage of being able to predict fish populations at all stages of their lifecycle. As the model is iterative, and matches well with observed data for upstream migration, it is also likely to be fairly accurate for salmonids in other stages of their lifecycle.

The simulation may also be used to predict future populations, an original goal. In addition, the simulation could also be recalibrated fairly easily to a wide variety of other rivers and streams.

Conclusion

Statistical methods, such as those that I presented in my research last year, accurately predict the relative frequency of the timing of fish populations migrating upstream when the explanatory variable, streamflow, is simple. However, in complicated cases, the fish populations are not predicted accurately enough. Over time, a simple statistical prediction accumulates too much error, making extrapolations useful only one or two seasons into the future.

By simulating the fish populations instead, a reasonable degree of accuracy is achieved for most situations—including for statistically "noisy" weather predictions. Given general trends in weather, predation, and other factors, a useful prediction of the fish populations can be found using simulation. Unfortunately, for overarching trends in upstream migration, the simulation's results are not significantly better than those obtained by statistical methods. However, because of the flexibility inbuilt into the simulation, it is useful in other ways.

The raw fish data used in constructing the simulation and prior statistical analysis have been incorporated into an automatically generated website, which will be available for free public access shortly.

Acknowledgments

I would like to take this opportunity to recognize the time and effort of Brenda Mallett for formatting and data entry, the review and assistance of Jane Orbuch and David Bernick, the research of Don Alley, the MBS&TP, and the California Department of Water Resources, and most importantly, the migration census data from Terry Umstead, with cooperation from the Monterey Bay Salmon and Trout Project.

Further Information

For further information, please contact me at ian@geometrian.com

In association with the San Lorenzo Valley Watershed Academy and the Monterey Bay Salmon and Trout Project, 2010